Validation of technology push strategies for achieving sustainable development in manufacturing organizations through structural equation modeling

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Abstract

Purpose – The purpose of this paper is to investigate and select various significant technology push (TP) strategies affecting sustainable development in manufacturing organizations. The study deploys structural equation modeling (SEM) technique to empirically validate the interrelationships amongst significant TP strategies and sustainable development indicators in SEM-TP Model.

Design/methodology/approach – Confirmatory factor analysis approach is utilized to generate an effective SEM-TP Model by using AMOS 21 (Analysis of Moment Structures) software. The data have been collected from different manufacturing organizations practicing TP strategies, using a well-framed TP questionnaire for the evolution of SEM-TP Model.

Findings – SEM modeling of various TP strategies like, innovative capability (IC), research and development, corporate strategy (CS) and export orientation towards achieving sustainable development in manufacturing industries has been performed. SEM-TP Model has been planned and reports obtained before and after modification indices (MI) of the model are correlated, which further establishes improvements in model's effectiveness. The research concludes that two TP strategies namely, IC and CS are found to be significant in the present context. These strategies have emerged as a foundation for several development initiatives and actively support manufacturing industries in achieving sustainable development. The results obtained from final model may support organizational managers and TP practitioners to improve the overall performance of manufacturing industries involved in the present study. The manufacturing enterprises will be able to frame or enhance their corporate strategies and innovative capabilities in a more appropriate way.

Research limitations/implications – In the present study, contributions of TP practices are determined to accomplish sustainable development in manufacturing industries. Otherwise, issue-wise independent modeling can also be performed to assess the importance of TP practices towards achieving quality and sustainable development under specific orientations.

Practical implications – The research gives priority to enhancement in the coordination among various TP practices and sustainable development parameters in the industries, to inculcate TP as a crucial strategy to meet challenges in global markets.

Social implications – It has been exhibited from model that adequate TP strategies can effectively contribute towards recognition of sustainable development to compete in the highly progressive markets. The results of various interrelationships among TP practices and sustainable development indicators in SEM-TP Model portray the effectiveness of TP practices for accomplishment of organizational and social ambitions.

Originality/value – The outcomes of the study will help organizational managers, HR executives and TP practitioners in manufacturing industries to know about the significant TP strategies to be followed holistically for achieving sustainable development.

Keywords Sustainable development, Structural equation modeling, Confirmatory factor analysis, Manufacturing industries, Technology push strategies

Paper type Research paper

World Journal of Science, Technology and Sustainable Development
Vol. 15 No. 1, 2018
pp. 72-93

2042-5945
DOI 10.1108/WJSTSD-08-2017-0022

1. Introduction

1.1 Context of research

Technology can be defined by a number of ways, most of which gives a description of manufacturing and product development industries. Martino (1983) suggested that technology is an overall utilization of means to provide commodities essential for corporal sustainability and contentment. Zhao and Reisman (1992) contribute to the definition of technology as per social planning, management and business. On the whole, technology denotes a vast area of persistent application of dimensions of the real life. It contains the whole thought of methodology applied on different spheres with their aggregate hardware and programing elements. As per Gregson (1994) new technology is frequently used to displace the old one. Technology is a stimulant for change. However, the change that results can be observed separately (as positive or negative) by different individuals or groups depending upon their approach with reference to change. Riccaboni and Pammolli (2003) analyzed connection among technical systems, local correspondence, and the global network of industries. Abbasi *et al.* (2017) discussed the findings of research conducted between 2013 and 2016, based on the promotion of technology layout for the creative industries. The roadmap presented in their work was built based on input from communities of creative and information and communication technologies (ICT) during the validation phases of the research. Therefore, the study is directed towards the development of latest technologies and related business models and expertise, and provides guidance for making strategies in this regard.

The Technology push (TP) strategy drives the product coordination philosophy of “if we build it, they will adopt it” owing to a number of fields. The TP strategies set up a discussion among technology managers about the fundamental principles and their driving forces. It was inferred that innovation is motivated by science and that consecutively stimulate technology (Chidamber and Kon, 1994). TP indicates that technology has independent objectives, which depends on determinants of technology (Howells, 1997). There are many definitions of sustainability which have been proposed by various researchers over the time. According to the World Commission on Environment and Development, sustainable development is a procedure of advancement where the utilization of assets, command on investments, arrangement of technological development (TD) and corporate revolution, are made persistent with subsequent and existing requirements. Sustainable development is arising as a world-wide key perception that we must acknowledge to accommodate socio-economical, technological and environmental challenges (Jovane *et al.*, 2008). The manufacturing industries have witnessed many challenges in last four decades, involving drastic changes in innovative capability (IC), research and development (RD), corporate strategy (CS), export orientation (EO), flexibility, customer satisfaction (CSA) and other related issues. These challenges are compelling the manufacturing organizations to adopt innovative methodology to develop new products, and to exploit sustainable manufacturing tools and techniques efficiently (Bogue, 2014).

1.2 Structural equation modeling (SEM) in manufacturing industries

Modeling of industrial manufacturing processes bears severe complications due to association with a number of independent variables. The independent variables (TP strategies) have strong impact on dependent variables (sustainable development indicators). Moreover, independent variables interact with each other and more approximations are needed to favorably model the production process. A conceptual theoretical structure called SEM was developed in 1970s to discover relationships among various independent and dependent variables. In addition to this, few researchers practiced SEM in their research. Vinodh and Joy (2012) used SEM in sustainable manufacturing practices and they studied sustainable manufacturing practices across various industrial fields and identified critical success factors for its accomplishment. Tan (2001) practiced SEM model for new product design and development. In the present study authors have used SEM technique to analyze the effects of TP strategies on sustainable development in manufacturing industries.

2. Literature review

Now-a-days, universal rivalry has entered each and every portion of the business around the world (Koberg *et al.*, 2003). Prosperity is created through industrialization and development of economy is well recognized by growth of manufacturing corporations. Moreover, the prosperity of a country depends on the excellence of its production capacity and that those who overcome manufacturing will eventually succeed in technological innovation (Yamashina, 2000). Kocak *et al.* (2017) reported that dedicated technology orientation lead to radical innovation, while responsive market regulation actively affects incremental innovation. TP is regarded as a fundamental practice for the development and diffusion of technical improvements in manufacturing industries. TP uses an adopter to accept the technology (Drury and Farhoomand, 1999). The manufacturing industries prosper in the light of market needs, whereas according to technical experts the change in technology is the critical factor for development (Chidamber and Kon, 1994). Manufacturing, stated as conversion of materials and data into assets for the contentment of human wants is the fundamental wealth-creating exercises in a country. Encouraging perfection in manufacturing arises as a vital objective of industry along-with society (Chryssolouris *et al.*, 2013). Technology has led to reduced manufacturing times, which proves to be more fruitful for a fundamental format. It helps in lessening set-up and processing time variability (Li, 2003). According to Gilgeous and Gilgeous (1999), there are activities practiced in industries which governs working condition of the business and contribute most to the manufacturing significance. As per TP and demand pull (DP) practitioners, and industrial managers, the field of TP-DP is continuously growing. The interactions among TP-DP strategies depend on industrial life cycles and status of local market (Choi, 2017).

The concept of TP was primarily given by Schon (1967) as the basic motivation and driving force at the back of innovation of new technologies. Innovation is guided by science and hence impels technology. TP strategy originates from acknowledgment of new technological methods for improving the performance of manufacturing industries (Chau and Tam, 2000). To compete globally, companies must become more efficient, flexible and customer oriented. The government plays a significant part in determining the competitiveness of firms. Furthermore, it provides supportive infrastructure and flexibility to firms that help them compete in the international market (Halachmi, 2002). The companies based on technology incorporate TP practices but these practices cannot be proclaimed as suitable or inaccurate to deal with sustainable development in manufacturing industries. It depends upon standardized framework, for instance, a particular business, an organization's history and so on (Brem and Voigt, 2009). An important understanding is that the low product cost is the main focus in deciding the foremost ability of technological innovation (Kim and Lee, 2009).

TP strategies prompt innovation and benefit the national innovators (Peters *et al.*, 2012). Innovation is a precise approach and regulated measure that encompasses all exercises to prosper and offer latest commodities and operations in an industry. It plays a significant role to achieve the requisite goals and sustainable development in the industries. It has been observed that the decision of a company to adopt new technologies is closely based on the entrepreneurial characteristics rather than managerial. Furthermore, the developing economies are likely to face challenges in future, as the multinational companies, hamstrung by the moderate development in their home markets are focusing towards emerging industries (Krishnan, 2012). Today's manufacturing scenario is illustrated by accelerated changes in market and enhanced competitive strategies. Majority of the companies are using similar manufacturing techniques, therefore the struggle is not only based on manufacturing approach, but how strongly a firm governs technology apropos its consumers (Singla *et al.*, 2017). Noh *et al.* (2016) proposed a model for services relevant to technology which leads to the sustainable development in industries. The pace at which changes in technology take place has been accelerated since few decades. In addition, service also has changed frequently because of closely affiliated technology-market-service system. In this connection, technological refinement and dynamic market needs can aid uncertain competitive situations in service oriented industries.

Hemphill (2016) described the technique of responsible innovation (RI) for development of enterprises. The study focused on the devotion of industry and idea of corporate social responsibility (CSR) that represents administrative ideology to improve RI in industries. It was concluded that expansion of CSR to innovation will influence both the beginners and necessary firms performing at the leading edge of innovation. Fatima (2017) investigated the role of globalization in the progression and circulation of technology across manufacturing industries operating in emerging and developing economies. The study analyzed the feasibility of different mediums of international technology transference, whether they push the firms operating in developing countries to innovate and as a result push them closer to the international technology sphere. Subsequent analysis of latest technology is pivotal for a sustainable and prosperous future. However, contiguous changes in the global markets impose challenges for long term policy and strategy making (Saritas *et al.*, 2016). According to Ndubisi (2012) achievement of high-quality and reliability standards demonstrates organizational capabilities which provide enormous advantages. Achieving high-quality standards by acquiring and practicing latest technologies is the primary motive of manufacturing companies. Industries try to regulate the cost and strengthen their corporate strategies and worth by terminating unwanted deviation in quality of products and services.

3. Significance of deploying SEM for evaluating sustainable development in manufacturing organizations

In manufacturing organizations, the traditional method such as regression technique is deployed for modeling the cause and effect to evaluate the predictive model when the regressor variable and criterion variable are continuous and measurable. When these variables comprise of other variables known as latent, dimensions and constructs variables, it requires more sophisticated techniques for analysis. The most significant technique to organize the latent or constructs variables is SEM in multivariate analysis (Javadin *et al.*, 2012; Garcia *et al.*, 2014). SEM has capability to clarify the direct as well as indirect effects among the interrelated variables and produce complete effects which is the final aggregate of both the direct and indirect effects, instead of multiple linear regression which just manages direct effects only (Keith, 2006; Agus and Hajinoor, 2012; Westland, 2012). SEM has found a number of applications in many areas along with economics and social sciences in which it is generated. It is a multivariate tool which look into the interrelationships between the indicator (observed or manifest variables) variables and latent variables while considering measurement error that may go with variables, to analyze relationships among endogenous variables (known as structural model in SEM), and between endogenous and exogenous variables (known as measurement model in SEM) (Blunch, 2008).

SEM has ability to evaluate, approximate, stipulate and portray models to demonstrate hypothesized interrelationships between variables through non rational path diagram. It has ability to deal with non-recursive models and has effective ability to solve the real life complex problems, which a multiple linear regression cannot frame because of certain problems and violations (Dogan, 2004; Beltrán *et al.*, 2014). SEM plays an important part in wide areas like, strategy planning, logistics, production process, industrial safety and ergonomics, industrial performance, decision making and environmental impacts of manufacturing organizations (Fullarton and Stokes, 2007; Ramanathan *et al.*, 2010; Cui *et al.*, 2013; Carmona-Márquez *et al.*, 2016).

SEM apparently permits both confirmatory and exploratory modeling that helps to formulate new theories as well as provide platform to test the theories. Many researchers have applied SEM in their studies (Punniyamoorty *et al.*, 2012; Beltrán *et al.*, 2014; Hair *et al.*, 2014; Mishra, 2014) for different accomplishments. The utilization of SEM in modeling manufacturing conditions is attempted by few researchers which designed the study. Literature review indicates that there is no actual evidence of usage of SEM in manufacturing industries particularly for TP strategies, which is nearly attainable in industries. The current study validates TP practices through SEM for achieving sustainable development in manufacturing industries using the data possessed from various manufacturing organizations.

4. Research methodology

The research has been conducted at medium and large scale manufacturing industries practicing TP strategies or at different levels of practicing them. The focus of investigation is on advancement of TP practices to have progressive manufacturing in industries. To analyze the inputs made by TP strategies towards achieving sustainable development a comprehensive "TP questionnaire" has been fabricated. The questionnaire has been drafted by executing a thorough literature survey. Figure 1 shows the methodology adopted for the study.

The questionnaire is then utilized to seek information on the situation of various TP strategies in manufacturing enterprises. A rationally extensive sample of manufacturing industries was investigated. Aside from this, miscellaneous interviews with TP

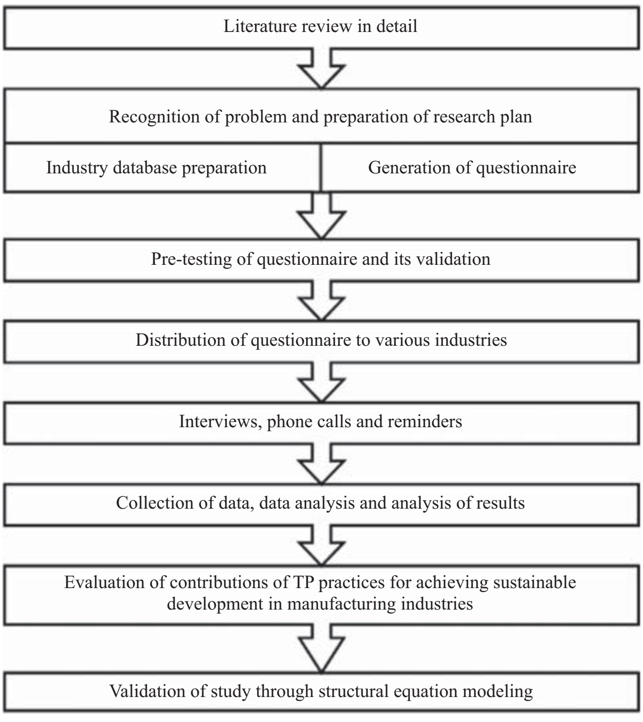

Figure 1.
Methodology deployed for the study

practitioners were made and explanations were arranged. In total, 92 valid responses were obtained. Finally, the data collected from the manufacturing organizations has been compiled and analyzed through SEM Technique using AMOS 21 software for obtaining concrete validations, to present the optimum fit of identified variables in SEM-TP model.

5. SEM for validating impact of TP strategies on sustainable development in manufacturing organizations

The study involves SEM analysis conducted through AMOS 21 software. SEM analysis covers various statistical analyses, like, path analysis, confirmatory factor analysis (CFA), causal modeling with latent variables, analysis of variance and multiple linear regressions. SEM analysis specifies estimates and evaluates models of linear correlations among a set of predictor attributes estimated, related to few outcome attributes (Shah and Goldstein, 2006; Kaur *et al.*, 2015).

Figure 2 portrays a model of three observed predictors predicting one outcome variable by developing SEM model representing the relationships between various predictor and

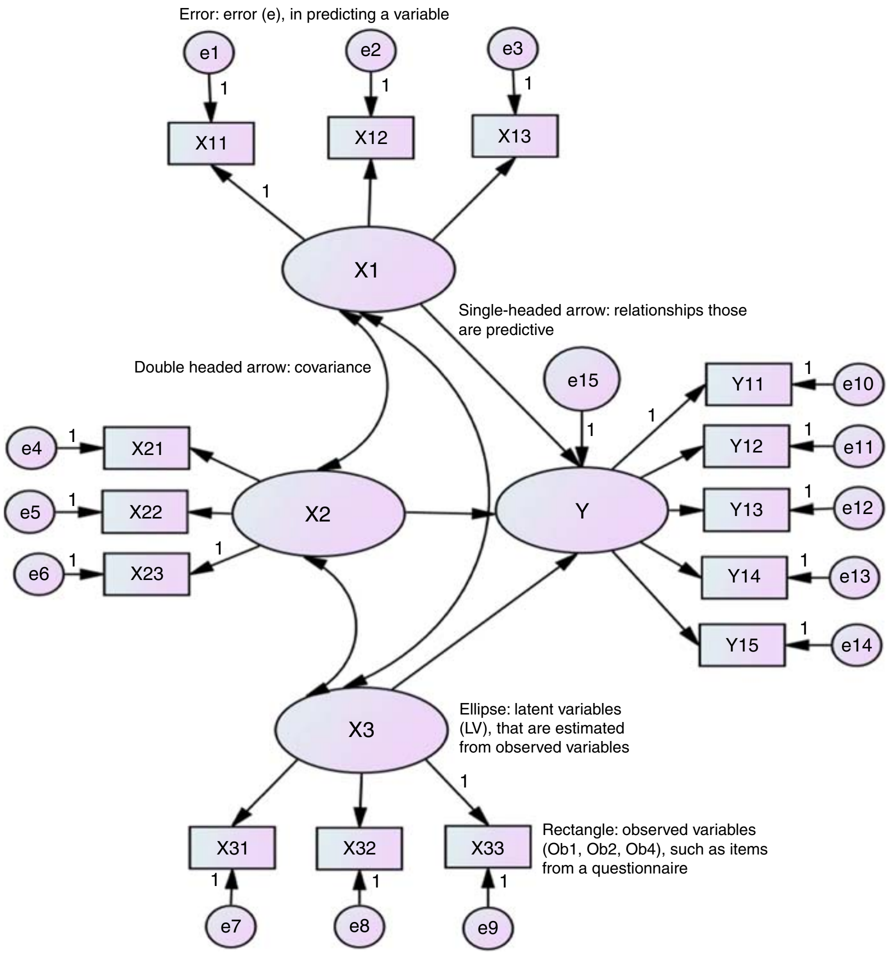

Figure 2.
SEM hypothesis indicating correlation between Predictors and Output Variable

outcome variables through path diagrams. The generation of SEM model indicating path diagrams requires specified procedures. SEM requires the ability to effectively translate the theoretical postulates, theories and inputs into a SEM model comprising of following elements. Table I shows standard cutoff criteria for several fit indexes.

As per literature review and analysis of multiple regression analysis, four independent constructs (IC; RD; CS and EO) and one dependent construct namely, sustainable development have been deployed to construct the SEM-TP model. Figure 3 depicts a systematic nomenclature of SEM-TP Model deployed in present study indicating various predictors and outcome variable. It illustrates the conceptual model constructed in this research work to examine the relationships between IC; RD; CS; EO and Sustainable Development (SD) by conducting an empirical analysis of manufacturing enterprises. Furthermore, the following four hypothesis (*H1*, *H2*, *H3* and *H4*) are also proposed to

Indexes	Shorthand	General rule for acceptable fit if data are continuous	Categorical data
Absolute/predictive fit			
Chi-square	χ^2	Ratio of χ^2 to df ⩽ 2 or 3, useful for nested models/ model trimming	
Akaike information criterion	AIC	Smaller the better; good for model comparison (nonnested), not a single model	
Browne-Cudeck criterion	BCC	Smaller the better; good for model comparison, not a single model	
Bayes information criterion	BIC	Smaller the better; good for model comparison (nonnested), not a single model	
Consistent AIC	CAIC	Smaller the better; good for model comparison (nonnested), not a single model	
Expected cross-validation index	ECVI	Smaller the better; good for model comparison (nonnested), not a single model	
Comparative fit		*Comparison to a baseline (independence) or other model*	
Normed fit index	NFI	⩾ 0.95 for acceptance	
Incremental fit index	IFI	⩾ 0.95 for acceptance	
Tucker-Lewis index	TLI	⩾ 0.95 can be 0 > TLI > 1 for acceptance	0.96
Comparative fit index	CFI	⩾ 0.95 for acceptance	0.95
Relative non centrality fit index	RNFI	⩾ 0.95, similar to CFI but can be negative, therefore CFI better choice	
Parsimonious fit			
Parsimony-adjusted NFI	PNFI	Very sensitive to model size	
Parsimony-adjusted CFI	PCFI	Sensitive to model size	
Parsimony-adjusted GFI	PGFI	Closer to 1 the better, though typically lower than other indexes and sensitive to model size	
Other			
Goodness of fit index	GFI	⩾ 0.95 Not generally recommended	
Adjusted GFI	AGFI	⩾ 0.95 Performance poor in simulation studies	
Hoelter 0.05 index		Critical N largest sample size for accepting that model is correct	
Hoelter 0.01 index		Hoelter suggestion, $N = 200$, better for satisfactory fit	
Root mean square residual	RMR	Smaller, the better; 0 indicates perfect fit	
Standardized RMR	SRMR	⩽ 0.08	
Weighted root mean residual	WRMR	< 0.90	< 0.90
Root mean square error of approximation	RMSEA	< 0.06 to 0.08 with confidence interval	< 0.06

Source: Schreiber *et al.* (2006)

Table I.
Criteria for cuttoff for several fit indexes

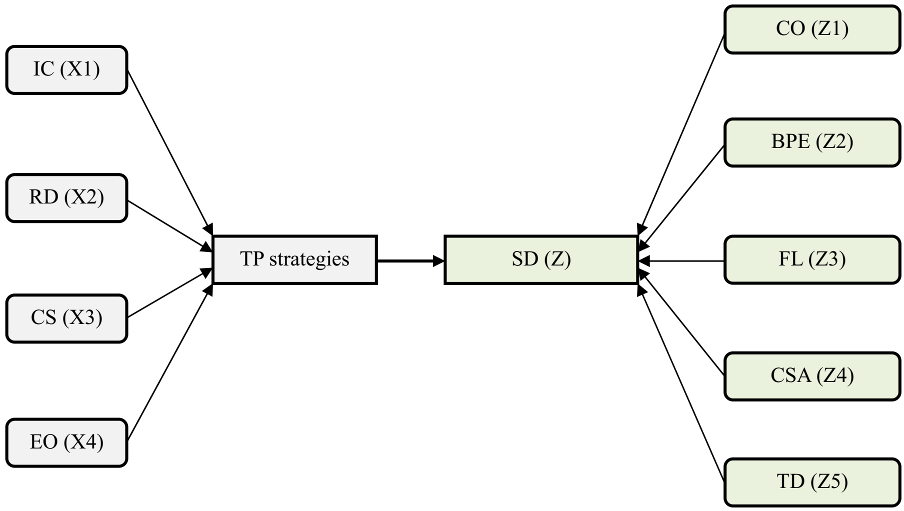

Figure 3. Systematic nomenclature of SEM-TP Model

examine the level of association between various input constructs and Sustainable Development indicators in manufacturing organizations:

H1. There exists a firm alliance between "Innovative capability" and "Sustainable Development."

H2. A substantial relation exists between "Research and development" and "Sustainable Development."

H3. There exists an adequate association between "Corporate strategy" and "Sustainable Development."

H4. A strong confident partnership exists between "Export orientation" and "Sustainable Development."

5.1 Predictor attributes (independent variables) utilized in SEM-TP Model

Table II presents the description of four independent variables derived from the multiple regression analysis. As per the literature review, these variables contribute towards achieving Sustainable Development in manufacturing organizations. The items chosen are not intended to be comprehensive measures, but sufficiently represent the essence of the relationships identified above in Figure 3.

5.2 Output/dependent variables considered in SEM study

Table III portrays dependent variables deployed in the study which holistically leads to accomplishment of sustainable development in manufacturing organizations through TP strategies. Five dependent variables have been formulated through extensive review of literature and consultation with industrial resource persons and academicians. These five variables are collected together and related by the term "Sustainable Development" in the SEM-TP model.

6. Analysis and formulation of SEM-TP Model

6.1 Preliminary investigation of data

The data obtained from various manufacturing organizations through a well-designed TP questionnaire has been subjected to certain necessary techniques for testing like "Skewness

Symbol	Independent variables	
X1	Innovative capability (IC)	X11 – Companies support innovative thinking and make use of new ideas X12 – Innovative ideas support technological advancements X13 – During the last five years, companies have introduced new products to the market X14 – Companies often first to introduce new products X15 – During the last five years, companies have introduced new or significantly improved methods of manufacturing X16 – Innovation is important in promoting technological advancements in companies X17 – Innovative tools used by companies that make products technologically sound X18 – Companies imbibe innovative technologies frequently X19 – Companies timely deliver new technology to the customers
X2	Research and development (RD)	X21 – Companies invests in R&D to develop new products X22 – Companies have government sponsored R&D to develop new technology and products X23 – R&D play a role in developing new technologies in companies X24 – Companies conduct R&D programs to have knowledge about latest technological developments X25 – R&D carried out by companies help in reducing cost of existing products X26 – R&D exploit externally available information in development of new technologies
X3	Corporate strategy (CS)	X31– Companies have successfully established well defined corporate strategy X32 – Companies extensively and thoroughly follow these strategies X33 – Corporate strategies of companies indicate the frequent introduction of new and innovative products X34 – Corporate strategies of companies emphasize on introduction of radically improved products X35 – Companies update and review corporate strategies periodically X36 – Corporate strategies help in sustainable development of companies X37 – Company policies are designed to have clean technology innovations X38 – Companies target a particular class of customers only
X4	Export orientation (EO)	X41 – Introduction of high-tech products in the international markets by companies X42 – Export of high technology manufactured products at a fast rate X43 – Export of new products by substituting old ones by companies X44 – Expansion of global export to launch new and innovative products X45 – Companies successful in exporting technologically advanced products X46 – Appropriate execution of export oriented activities in companies

Table II.
Description of independent variables

Symbol	Dependent variables (sustainable development indicators)
Z1	Competitiveness (CO)
Z2	Business performance enhancements (BPE)
Z3	Flexibility (FL)
Z4	Customer satisfaction (CSA)
Z5	Technological development (TD)

Table III.
Dependent variables with abbreviations

and Kurtosis" to evaluate the normality of collected data; "CFA" to check the regression weights; and "Cronbach's α" to evaluate data reliability, in order to obtain confidence level and to determine accuracy in the collected data (Tan and Wong, 2015; Dandagi *et al.*, 2016). The data processing has been done through SPSS-AMOS 21 software to evaluate correlations between various attributes utilized in the research to construct SEM-TP model. The results obtained from SEM analysis determines the significant variables, which predicted the constructs better and also figure out the behavior of relationships among different constructs. The SEM analysis requires multivariate normally distributed data sample. The multivariate test calls upon screening of variables for normality (Tabachnick and Fidell, 2007). The present study tests the univariate normality, since AMOS or SPSS software do not support testing the multivariate normality of sample data.

The Skewness is related to equivalence of distribution. The skewed variable does not have mean in middle of distribution (Hatcher, 1994). Kurtosis being recognized as peakedness of a distribution, determines the extent of data with respect to normal distribution (Pallant, 2005; Kaur *et al.*, 2015; Singh and Khamba, 2015; Tan and Wong, 2015; Dandagi *et al.*, 2016). Table IV presents the descriptive statistics of all attributes for independent as well as dependent variables of SEM-TP model, in which the acceptable values of skewness ($\leqslant 2$) and kurtosis ($\leqslant 7$) are within the range according to Currie *et al.* (1999). Thus the distribution of data used for SEM-TP model does not depart from normality.

6.2 CFA

The Bartlett's test of sphericity is applied to verify the strength of inter-correlations among the items, while Kaiser-Meyer-Olkin (KMO) test has been applied to validate the ability of sample size through exploratory factor analysis (EFA) to determine the findings of data

	N	Minimum	Maximum	Mean	SD	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	SE	Statistic	SE
X11	92	2.00	5.00	4.1739	0.70491	−0.451	0.251	−0.178	0.498
X12	92	2.00	5.00	4.0435	0.79715	−0.345	0.251	−0.658	0.498
X13	92	1.00	5.00	3.7391	1.05736	−0.767	0.251	0.221	0.498
X14	92	1.00	5.00	3.2283	1.04937	0.051	0.251	−0.463	0.498
X15	92	2.00	5.00	3.7500	0.89719	−0.041	0.251	−0.918	0.498
X16	92	2.00	5.00	3.8261	0.79295	−0.218	0.251	−0.405	0.498
X17	92	1.00	5.00	3.9348	0.82281	−0.482	0.251	0.437	0.498
X18	92	1.00	5.00	3.5326	0.84452	−0.272	0.251	0.042	0.498
X19	92	1.00	5.00	3.8587	0.89665	−0.463	0.251	−0.025	0.498
X21	92	1.00	5.00	3.4783	1.41792	−0.57	0.251	−0.986	0.498
X22	92	1.00	5.00	2.3913	1.28351	0.343	0.251	−1.202	0.498
X23	92	1.00	5.00	3.3696	1.33192	−0.654	0.251	−0.851	0.498
X24	92	1.00	5.00	3.1413	1.27168	−0.402	0.251	−0.817	0.498
X25	92	1.00	5.00	3.3478	1.34601	−0.608	0.251	−0.79	0.498
X26	92	1.00	5.00	3.1630	1.32828	−0.22	0.251	−1.068	0.498
X31	92	2.00	5.00	3.9891	0.79136	−0.117	0.251	−1.044	0.498
X32	92	2.00	5.00	3.9130	0.76535	−0.001	0.251	−0.927	0.498
X33	92	1.00	5.00	3.4891	0.94339	−0.169	0.251	−0.521	0.498
X34	92	1.00	5.00	3.5435	0.91883	−0.348	0.251	−0.334	0.498
X35	92	2.00	5.00	3.7609	0.81698	−0.024	0.251	−0.684	0.498
X36	92	2.00	5.00	3.8587	0.83313	−0.194	0.251	−0.671	0.498
X37	92	2.00	5.00	3.8478	0.85079	−0.358	0.251	−0.439	0.498
X38	92	1.00	5.00	3.2391	1.12288	−0.346	0.251	−0.34	0.498
X41	92	1.00	5.00	2.9348	1.59535	0.026	0.251	−1.578	0.498
X42	92	1.00	5.00	2.9022	1.48294	−0.014	0.251	−1.393	0.498
X43	92	1.00	5.00	2.6522	1.48572	0.211	0.251	−1.467	0.498
X44	92	1.00	5.00	2.9674	1.50056	−0.103	0.251	−1.417	0.498
X45	92	1.00	5.00	3.0217	1.45993	−0.212	0.251	−1.348	0.498
X46	92	1.00	5.00	3.0435	1.41354	−0.102	0.251	−1.254	0.498
Z1	92	2.13	5.00	3.7149	0.64957	−0.435	0.251	−0.513	0.498
Z2	92	2.78	5.00	3.9010	0.61205	0.173	0.251	−1.029	0.498
Z3	92	2.13	5.00	3.7127	0.55787	−0.222	0.251	−0.071	0.498
Z4	92	3.00	5.00	4.1083	0.50389	−0.124	0.251	−0.738	0.498
Z5	92	2.13	5.00	3.7388	0.70192	−0.238	0.251	−0.758	0.498
Valid *N* (listwise)	92								

Table IV. Descriptive statistics analysis of Skewness and Kurtosis for both predictor and dependent attributes of SEM-TP model which means if it is suited for CFA (Pallant, 2005; Ikediashi *et al.*, 2013; Singh and Khamba, 2015; Tan and Wong, 2015). The significance level at $p < 0.05$ for CFA is considered suitable for Bartlett's Test of Sphericity, while KMO index must lie between 0 and 1, with lowest acceptable CFA value of 0.5 (Tabachnick and Fidell, 2007). Table V shows the results of KMO test (> 0.800) and Bartlett's Test of Sphericity (significant p values 0.000) for the independent and dependent variables, which indicate that data are suited to continue with the procedure of CFA.

Figures 4-8 exhibit the path diagrams of CFA for all predictor and dependent attributes of SEM-TP model (Chinda and Mohamed, 2008; Singh and Khamba, 2015; Dandagi *et al.*, 2016). A few items in variables need to be removed from the CFA diagrams whose standardized regression weights are less than 0.60, since these predictor attributes might contribute towards the SEM-TP model to unfit (Rakowski *et al.*, 1997). The items X16 and X19 from the independent variable IC are removed because their standardized regression weight values are < 0.60. Similarly, X22 and X38 are omitted from RD and CS, respectively.

Table V. KMO and Bartlett's Test for predictor and dependent attributes of SEM-TP Model

Variables	Kaiser-Meyer-Olkin measure	Bartlett's test of sphericity χ^2 value	p-value
IC (X1)	0.864	427.774	0.000
RD (X2)	0.916	506.355	0.000
CS (X3)	0.824	378.321	0.000
EO (X4)	0.916	583.727	0.000
SD (Z)	0.866	328.693	0.000

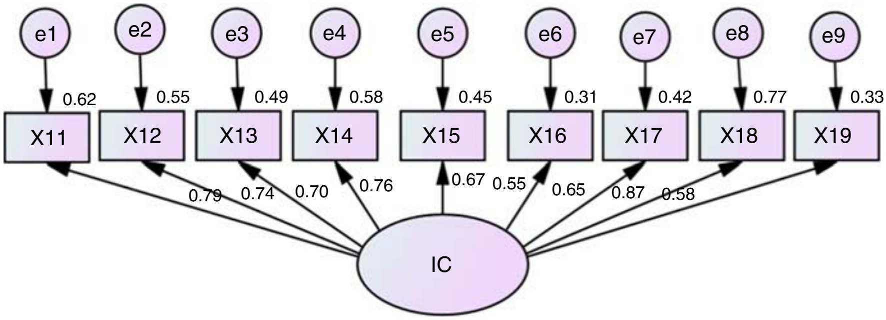

Figure 4. Path diagram of CFA for innovative capability (IC)

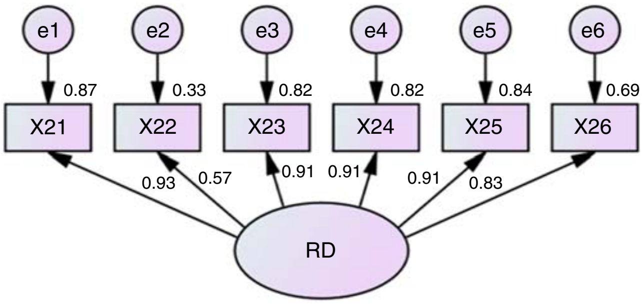

Figure 5. Path diagram of CFA for research and development (RD)

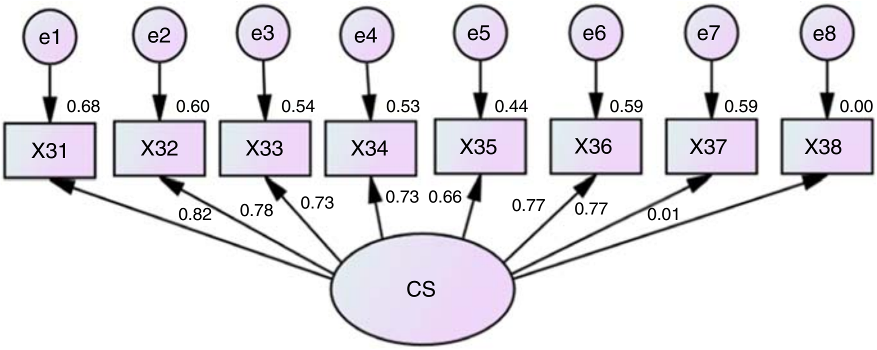

Figure 6. Path diagram of CFA for corporate strategy (CS)

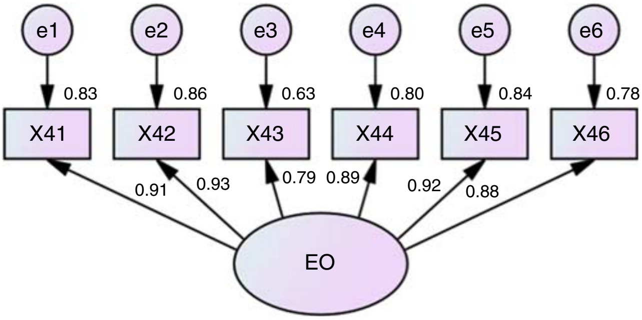

Figure 7. Path diagram of CFA for export orientation (EO)

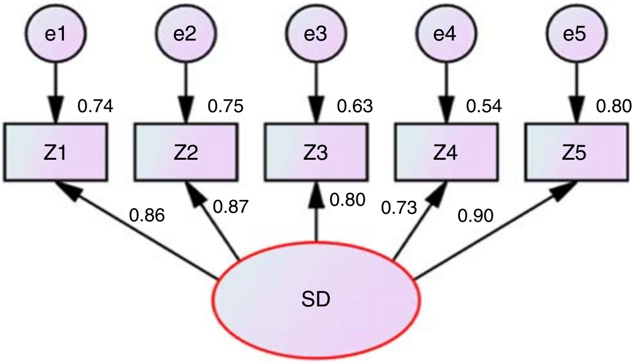

Figure 8. Path diagram of CFA for sustainable development (SD)

These items have not been included in the SEM-TP model, while the rest of items from remaining independent variables and dependant attributes with standardized regression weights > 0.60 are considered in the SEM-TP model.

After omitting insignificant items from their respective variables, it is necessary to test data reliability using Cronbach's α test in SPSS software (Nunnally, 1978; Ikediashi *et al.*, 2013). The data having Cronbach's α reliability value > 0.7 is considered appropriate to proceed for SEM analysis. Table VI depicts that Cronbach's α values are above 0.8 for various attributes, thereby increasing confidence level in data.

6.3 Original SEM-TP model and analysis of results

A complete SEM-TP Model exhibited in Figure 9 has been developed by utilizing the software AMOS 21 for evaluating the relationships amongst various attributes involved in the research. The study exhibits the linkage of independent constructs with regression coefficients in an unstandardized SEM-TP model. The output of AMOS for an unstandardized model furnish number of relationships such as covariance between predictor attributes, ordinary regression coefficients, error measurement of each predictor attributes and significance level (*p*-value) for each relationship. The path analysis diagram for the constructs and refined variables with regression coefficients in the model have been depicted in Figure 9.

In CFA, the factor structure is confirmed which has been extracted in the EFA by applying constraints on the relationship between the observed variables and the latent factors. In the confirmatory approach, the observed variables are allowed to load on to the constructs they belong to and cross loadings are not allowed. The outputs received from the original model have been compared with cutoff criteria for Several Fit Indexes described by various researchers (Schreiber *et al.*, 2006; Chinda, and Mohamed, 2008; Hazen *et al.*, 2015; Motawa and Oladokun, 2015; Dandagi *et al.*, 2016; Tripathy *et al.*, 2016). It is observed that RMR (root mean square residual) assessment for unstandardized model is (0.063), which is very much close to 0, thus indicating near perfect fit of the model. RMR depicts absolute value of covariance residuals and is computed as square root of average squared amount by which variances of sample and covariance's vary from their approximations. Thus low values of RMS are always preferred (< 0.08 for acceptable model).

The value of goodness of fit index (GFI) is 0.599 which should range from 0 to 0.95. It is an alternate to chi-square test and computes the proportion of variances that is accounted by approximating population covariance (Jeong and Phillips, 2001; Tabachnick and Fidell, 2007). Adjusted goodness fit index (AGFI) value for SEM model has been observed to be 0.824 that depends upon the degrees of freedom with more saturated models reducing fit. The model is considered to be perfect fit with GFI and AGFI indices approaching 0.95.

Statistics for the structural model are presented in Figure 9 and Table VII. Table VII depicts the hypothesis testing results for the causal effects of IC, RD, CS and EO on SD (Ikediashi *et al.*, 2013; Motawa and Oladokun, 2015; Tan and Wong, 2015; Dandagi *et al.*, 2016; Tripathy *et al.*, 2016). It has been observed that CS (X3) and IC (X1) are significant for SD, while RD (X2) and EO (X4) are not. The relationship between "Innovative capability" and "Sustainable Development" is relevant and significant ($\beta = 0.269$, $p = 0.050$), thereby validating *H1*. Similarly "Corporate strategy" has been observed to be strongly associated with "Sustainable Development" with $\beta = 0.833$ and $p = 0.002$; hence, validating the relevance and significance of *H3*.

On the flipside, "Research and development" do not exhibit strong association with "Sustainable Development" ($\beta = -0.171$, $p = 0.394$), thereby not validating the *H2*. However, the negative sign indicates the need for manufacturing industries to further strengthen "Research and development" strategy. In addition to this, *H4* cannot be validated in the present context, since the study reports poor association among "Export orientation" and "Sustainable Development" with $\beta = 0.098$ and $p = 0.416$. This can be attributed to the fact

Input segment	IC	RD	CS	EO
Number of items	7	5	7	6
Cronbach's α values	0.888	0.954	0.900	0.956
Output segment		SD		
Number of items	5			
Cronbach's α values	0.962			

Table VI. Values of Cronbach's α for all variables after the omitting items

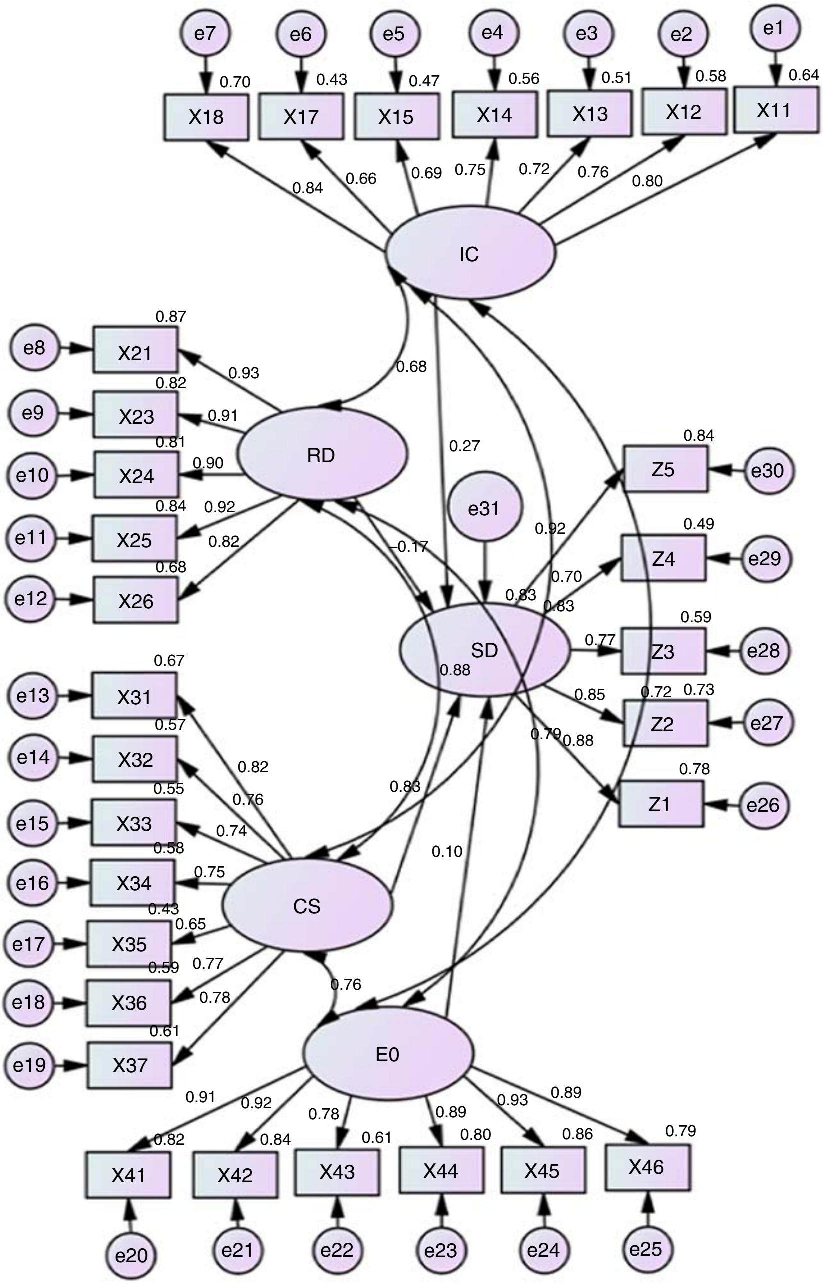

Figure 9.
SEM-TP Model original (Standardized Estimates)

that TP is not just a one-time short term practice for achieving sustainable development in manufacturing organizations.

Certainly, the review acknowledges that there is a positive association of two TP practices namely, IC and CS with sustainable development.

6.4 MI of SEM-TP model

Table VIII presents the MI obtained from AMOS 21 software, which is utilized to modify the original unstandardized SEM-TP model. MI depicts changes in structure of the model and demonstrates improvements in fit, presented by incorporating specific additional relationships in SEM-TP model. The selection of MI should be made based on threshold values to reduce the display of MI to a smaller set. MI for a parameter helps to determine the extent by which discrepancy function would decrease, if analysis were repeated with removed constraints on that parameter. The actual decrease that would occur may be much more. The modified SEM-TP model and its outputs have been depicted in Figure 10.

6.5 SEM-TP model after modification

Figure 10 is the CFA model after addressing the misspecifications in the model. MI offer suggested remedies to discrepancies between proposed and estimated model. The error terms were allowed to co-vary after which the model fit improves to some extent. The CMIN/df improved from 1.724 to 1.467 but at the cost of reduced degree of freedom. The goodness of fit indices improved marginally but remained below the recommended level. Figure 10 describes modified SEM-TP Model upon inclusion of various relationships as described by MI in Table VIII. It has been established that the significant TP strategies, like, IC, RD, CS and EO have direct effect on sustainable development indicators, namely, competitiveness (CO), business performance enhancements, flexibility (FL), CSA and TD.

Statistics for the structural model after application of MI are presented in Figure 10 and Table IX. Table IX depicts the hypotheses testing results for the causal effects of IC, RD, CS and EO on SD (Ikediashi *et al.*, 2013; Motawa and Oladokun, 2015; Tan and Wong, 2015;

Endogenous construct	Exogenous construct	Hypothesis	Path Coefficients (β)	SE	CR	Significance p	Support/ non support	Accepted/ rejected
IC (X1)	SD (Z)	*H1*	0.269	0.151	1.015	0.050	Support	Accepted
RD (X2)	SD (Z)	*H2*	−0.171	0.117	−0.852	0.394	Non support	Rejected
CS (X3)	SD (Z)	*H3*	0.833	0.263	3.07	0.002	Support	Accepted
EO (X4)	SD (Z)	*H4*	0.098	0.062	0.814	0.416	Non support	Rejected

Table VII.
Path analysis for the constructs of the study

Covariance's of items	MI	Par change
e16 ↔ e15	18.602	0.185
e29 ↔ e28	13.321	0.052
e14 ↔ e13	12.206	0.091
e4 ↔ e3	11.928	0.202
e4 ↔ e1	10.03	−0.109
e22 ↔ e21	9.144	0.194
e15 ↔ e13	8.902	−0.098
e6 ↔ e3	7.146	−0.136
e24 ↔ e22	5.980	−0.149
e19 ↔ e16	5.649	−0.086
e5 ↔ e1	5.102	0.071
e28 ↔ e27	4.968	0.030
e7 ↔ e6	4.782	0.073
e6 ↔ e4	4.677	−0.105
e25 ↔ e24	4.494	0.093

Table VIII.
Modification indices for SEM-TP model

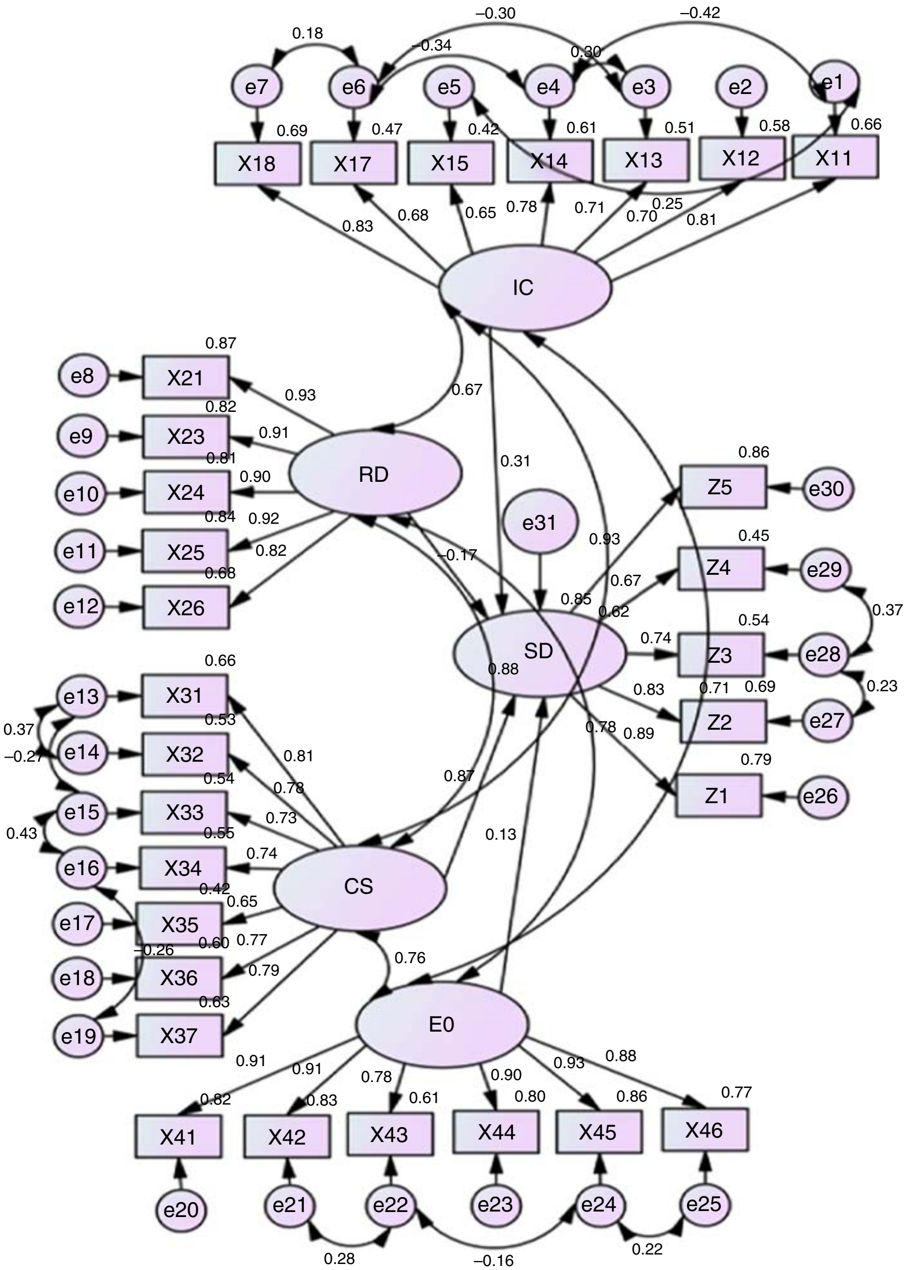

Figure 10.
SEM-TP Model after modification (Standardized Estimates)

Dandagi *et al.*, 2016; Tripathy *et al.*, 2016). Two paths (IC and CS) support SD, while RD and EO do not. The relationship between input constructs “Innovative capability”; “Corporate strategy” and “Sustainable Development” is relevant and significant (high β coefficients, p values < 0.05), thereby validating *H1* and *H3*. However *H2* and *H4* could not be validated in the present context, since the study reports poor association between "Research and development"; "Export orientation" and "Sustainable Development" with low β values of 0.172, 0.135 and p values of 0.398, 0.253, respectively. The results reveal that revised SEM-TP model (after MI) portrays better results as compared to the original SEM-TP model.

Table X shows the model fit summary of SEM-TP model before and after the MI (Ikediashi *et al.*, 2013; Singh and Khamba, 2015). After accomplishment of required modification in the original model, it has been observed that there is an improvement in the fitness values of modification model. CMIN/df value has shown improvement from 1.724 to 1.467, RMR index has been improved from 0.063 to 0.060 and root mean square error of approximation (RMSEA) has been improved from 0.096 to 0.072 according to recommended values for perfect fit of model. Similarly, GFI and AGFI indices have also been improved from their pervious values according to the recommended values for perfect fit of the model. The SEM-TP Model statistics consists of other indices which confirm the perfect model fit such as, comparative Fit Index (CFI), incremental fit index (IFI) and Tucker-Lewis Index (TLI). It is evident from Table X that the values of these indices have also shown improvement from previous unstandardized SEM-TP model, to get closer to the recommended values for perfect model fit.

In the present research, it has been observed that GFI index has been found to be 0.938 after MI from 0.886 before MI. This moderate value of MI compared to an ideally proposed value of 0.95 can be attributed to many factors. Since, this is first of its kind study to evaluate contributions of TP strategies in achieving Sustainable Development, it can be considered to be a primary study. The literature suggests that the higher values of GFI are usually observed during maturity stages of research. Another reason for moderate value of GFI index can be attributed to the fact that in the present context "Research and development" factors have been found to bear a negative correlation with "Sustainable Development" parameters.

Table IX.
Path analysis for constructs of the study for revised SEM-TP model

Endogenous construct	Exogenous construct	Hypothesis	Path coefficients (β)	SE	CR	Significance p	Support/non support	Accepted/ rejected
IC (X1)	SD	*H1*	0.310	0.144	0.707	0.048	Support	Accepted
RD (X2)	SD	*H2*	−0.172	0.121	−0.846	0.398	Non support	Rejected
CS (X3)	SD	*H3*	0.873	0.265	3.177	0.001	Support	Accepted
EO (X4)	SD	*H4*	0.135	0.062	1.144	0.253	Non support	Rejected

Table X.
SEM-TP model statics (Before and After Modification Indices)

Model fit summary	Before modification indices model	After modification indices model	Recommended value for model fit*
CMIN/df	1.724	1.467	χ^2/df < 3.0
df	395	380	Smaller is better
Probability level	0.00	0.00	
RMR	0.063	0.060	Smaller is better; 0 indicates perfect fit
RMSEA	0.096	0.072	< 0.08
Baseline comparisons			
GFI Index	0.886	0.938	> 0.95
AGFI Index	0.824	0.879	> 0.95
CFI Index	0.892	0.933	> 0.95
IFI Index	0.894	0.934	> 0.95
Tucker-Lewis Index (TLI)	0.881	0.923	> 0.95

Note: *It is recommended that the model value should be close to the recommended values mentioned under this column to ensure improved model fit

Furthermore, the moderate value of GFI index can also be attributed to the fact that in this study only 92 responses have been deployed to investigate the impact of various TP strategies on sustainable development. The literature also suggests that in Covariance-based SEM (CB-SEM) 20:1 (sample size to estimated parameter) ratio is considered as ideal; whereas Hair *et al.* (2010) suggests that 10:1 is minimally acceptable (Kline, 2011). In present study, the ideal sample size should be 100, whereas the actual sample is 92. Approximately 36 percent of CB-SEM articles published in *International Journal of Logistics Management*, *International Journal of Physical Distribution and Logistics Management*, and *Journal of Business Logistics* had sample sizes below 200, with a few below 100 (Hazen *et al.*, 2015). This might also have some influence on GFI. In future, the study involving reasonably higher number of responses may lead to higher value of GFI. Therefore, it is suggested that for attaining higher GFI, an advanced research involving a large number of responses can be conducted as a future work.

For GFI, AGFI and CFI, a generally suggested minimum value for a very good fit is 0.90; the ratio of χ^2/df is recommended to be less than 3.0 (Segars and Grover, 1993). Similar GFI indices below 0.95 have also been reported in various other studies, like Motawa and Oladokun (2015) reported GFI index from 0.774 to 0.923 and Tripathy *et al.* (2016) have reported GFI of 0.911. Since, this model meets other Goodness of Fit Indices of CMIN/df < 3, $p < 0.001$, RMSEA $= 0.072$, CFI, IFI and TLI indices close to 0.9, therefore in the present context, this SEM model meets the Goodness of Fit requirements. Theoretically, the model seems to be sound and applicable. Hence, it may be suggested that more data should be possessed and model be tested on a larger data set.

7. Conclusions

In the present paper, SEM-TP Model has been fabricated using AMOS 21 software and the research has been validated through it. The empirical investigation of data (collected through TP questionnaire) using SEM-TP model is aimed at evaluating the effects various endogenous constructs like IC, RD, CS and EO on exogenous construct SD. The data investigation methodologies for instance, test for skewness and kurtosis, to verify the normality of independent and dependent variables are adapted in the study. The elements of independent and dependent variables which make SEM-TP model unfit have been omitted using CFA approach. SEM has been exercised on the data using AMOS 21 software. Further, the statistical data before and after MI has been analyzed and a final SEM-TP model was observed closer to near fit values. The final model has shown the improvements in model effectiveness. It has been observed from refined SEM-TP model that TP strategies such as IC and CS have performed extremely well towards accruing Sustainable Development in manufacturing organizations. The final model can guide HR executives, practitioners of TP strategies and organizational managers to build corporate strategies and innovative capabilities more effectively.

The analysis empirically validates that IC is a highly significant variable. It supports innovative thinking and makes use of new ideas and further supports technological advancements. Innovation is considered important in assisting the companies to introduce new innovative products into market frequently. Furthermore, CS is another relevant variable procured from analysis. Hence, it is evident from results that most of the industries considered in the survey follow their corporate strategies meticulously. The companies update and review their corporate strategies periodically to improve business performance.

The present study has few limitations also. First, no study in the past has reported the combination of exactly same constructs together, although all variables deployed in this study have been adapted from extensive literature review. Therefore, it is difficult to precisely correlate the equation coefficients with results of earlier studies. Another limitation is that the survey has been conducted in Indian manufacturing organizations only.

Hence, the results obtained from this empirical investigation conducted via SEM will need some modifications before applying to other geographic locations. In future, studies could be undertaken in other emerging economies and developed economies to unfold the dependency of "Sustainable Development" on different independent variables.

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